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Ontology for the Gridded Met Database

by Edward M. Measure

ARL-TR-4172 July 2007

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ARL-TR-4172 **July 2007**

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REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. REPORT DATE *(DD-MM-YYYY)*	**2. REPORT TYPE**	**3. DATES COVERED (From - To)**
July 2007	Final	

4. TITLE AND SUBTITLE
Ontology for the Gridded Met Database

5a. CONTRACT NUMBER

5b. GRANT NUMBER

5c. PROGRAM ELEMENT NUMBER

6. AUTHOR(S)
Edward M. Measure

5d. PROJECT NUMBER

5e. TASK NUMBER

5f. WORK UNIT NUMBER

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
U.S. Army Research Laboratory
Computational and Information Sciences Directorate
Battlefield Environment Division (ATTN: AMSRD-ARL-CI-EE)
White Sands Missile Range, NM 88002-5501

8. PERFORMING ORGANIZATION REPORT NUMBER
ARL-TR-4172

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)
U.S. Army Research Laboratory
2800 Powder Mill Road
Adelphi, MD 20783-1197

10. SPONSOR/MONITOR'S ACRONYM(S)

11. SPONSOR/MONITOR'S REPORT NUMBER(S)
ARL-TR-4172

12. DISTRIBUTION/AVAILABILITY STATEMENT

13. SUPPLEMENTARY NOTES

14. ABSTRACT

The concept of net-centricity requires not only interconnection of individual soldiers, but of their machines. Processing the vast ocean of information from sensors and the Internet will require sophisticated machine-to-machine communication and interoperability. By attaching semantic markup or meaning to information, the Semantic Web takes a large step in advancing human-machine and machine-machine communication. In this report, we describe the development of an ontology designed to capture much of the semantic information in the Gridded Meteorological Database (GMDB). In part, the ontology developed is based on the GMDB metadata descriptions; however, the ontology developed goes beyond the metadata description in that it contains information about the semantic relationships between the metadata entities and attributes that the metadata descriptions do not capture. The ontology developed and described here is essentially a prototype. An operational version should incorporate both an expanded set of meteorological and meteorological effects entities and have a more detailed semantic structure.

15. SUBJECT TERMS

16. SECURITY CLASSIFICATION OF:			**17. LIMITATION OF ABSTRACT**	**18. NUMBER OF PAGES**	**19a. NAME OF RESPONSIBLE PERSON**
a. REPORT	**b. ABSTRACT**	**c. THIS PAGE**			Edward M. Measure
U	U	U	SAR	50	**19b. TELEPHONE NUMBER** (*Include area code*) 505-678-3307

Standard Form 298 (Rev. 8/98)
Prescribed by ANSI Std. Z39.18

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Preface

The Gridded Met Database (GMDB) contains meteorological information, which the Integrated Weather Effects Decision Aids (IWEDA) use to evaluate weather effects on Army systems. It consists of a gridded array of atmospheric parameters derived from the Integrated Meteorological System (IMETS), atmospheric models, and the weather running estimate. This report describes and discusses an ontology that has been developed to describe the GMDB parameters, their properties, and their relationships.

Because the modern notion of ontology is relatively unfamiliar to most in the military meteorology community, I also discuss the nature of a computer ontology and how it is intended to facilitate the goals of the Semantic Web.

For those unfamiliar with the modern concept of an ontology, consulting a dictionary might not be much help, since mine defined ontology as the study of the nature of being and existence. Not for the first time, developments in computer science have forced the invention of new terms or the expropriation of old words for new uses. Such is the case with ontology, a venerable but obscure word previously mainly of concern to theologians and philosophers. The circumstance that prompted its adaptation to the computer world is the need to make information, especially Web information, somewhat understandable to computers as well as to people. The motivation for ontology construction is to provide the context for computer systems to make use of the semantic content of the information they process.

This document is best viewed as a Web document, since references and other elements of the text are hypertext links to the Web whenever possible.

Acknowledgment

The Metadata file for the Gridded Meteorological Database (GMDB) was prepared by Leslie Johnson, a former student researcher at the U.S. Army Research Laboratory. It was the source of most of the data used in the construction of the GMDB ontology, and I have attached it to this report as an appendix.

Executive Summary

Overview

The World Wide Web and related technologies have vastly increased the amount of information potentially available to any user. One of the largest information stores is that associated with weather. Truly enormous amounts of data are collected by satellites, weather radars, the vast array of surface sensors, and other sensors such as the radiosonde.

The goal of the Semantic Web initiative is to make this information available to computers as well as individuals. A key component of the Semantic Web initiative is the development of ontologies, essentially controlled and specified vocabularies that permit information technology to "understand" data that has not been specially formatted for them.

The primary purposes of the present report are to discuss the fundamental principles of ontology development and to present an ontology developed for the data comprising the Gridded Meteorological Database (GMDB), a key element of the Integrated Meteorological System (IMETS) and Integrated Weather Effects Decision Aids (IWEDA).

The Substrate

The GMDB contains meteorological information derived from the forecast grids of mesoscale meteorological models. The ontology developed in this report is intended to capture the scope of this data and the primary relationships among the component parts. The relationships captured are based on, but not strictly derived from, the information in the GMDB metadata file.

Conclusions and Recommendations

The example of the GMDB presents some, but by no means all, of the challenges faced by a more general ontology of weather and battlefield weather effects. A critical question is whether this limited scale model can be expanded to encompass the much larger vocabulary of all battlefield weather effects, or the even larger vocabulary of meteorology. In addition, there is the question of encoding the more general mathematical and geospatial concepts that play a vital role in the description of atmospheric phenomena and their effects.

I believe the results to date suggest that the attempt is well worthwhile and has a reasonable prospect for success.

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1. Ontologies and the Semantic Web

1.1 Search and Discovery

As of June 24, 2005, the Google search engine indexes over 8 billion Web pages. It and other search engines are powerful tools for seeking needles in this very large haystack, but very obvious limitations remain. One of these can be illustrated with a simple example: suppose we do a search on the words "crib" and "sheet." My Google search on these words turned up 2,400,000 hits, but the first several concerned one or other of the following two possibilities: A "crib sheet" interpreted as a cloth sheet used in a baby's crib or, alternately, as a condensed list of facts and formulas such as might be helpful to a student on a test. The search ambiguity in the example is due to the fact that the search engine searches for words or phrases, and most words and phrases have multiple meanings. It is very easy for humans to resolve such ambiguities, which is why the search engine is such a powerful tool for us. What is obvious to a person, though, is not necessarily so for a computer.

A related type of search failure occurs when the words we choose to describe the searched for document are not the exact words used in the document, but roughly synonymous. Most of us recognize the words "girl,'' "woman," and "lady" as approximately equivalent. Suppose we vaguely remembered Sir Walter Scott's "The Lady of the Lake." A search for the quoted phrase finds lots of references to the work and the character. If our memory was less precise and we searched for "The Girl of the Lake," we would find a few references to an apparently rather different comic book character.

If I were searching for John Jones, I might want to narrow it down by saying "John Jones, the person, about 30 years old, living at …." Today's Web documents and search engines can't usually accept that type of clarification. The content of the documents needs to be supplemented by some additional information in order to support that type of search. Specifically, it needs to be supplemented by *semantic* information, that is, information that clarifies the meaning of the words in the documents.

I recently encountered yet a third type of "search failure" while searching for some information on the author of a book on general relativity. Since the author's name was a relatively uncommon one, I wasn't too surprised to see two main types of links to come up – one set apparently referencing a mathematics professor, and another set a professional artist. My "semantic processing" brain decided that the math professor was the guy, but as it turned out, they both were—the math professor had made a mid-life career change to artist.

These and other search engine “failures” are not isolated failings of search engines, but it is symptomatic a larger problem that inhibits many types of human-machine cooperation on the Web. Present day computers are limited by the fact that they don’t “understand” the content of the documents they can access. One of the goals of a relatively new initiative called “the Semantic Web” is to make Web documents more “understandable” to computers.

1.2 Semantics and Understanding

When we view a document written in an unfamiliar language, or using a lot of words or symbols we don’t know, or even a picture of an object of unfamiliar purpose, we fail to fully understand that document. We members of the human race have a lot of specialized hardware (or wetware) in our heads that is devoted to extracting meaning from words and pictures, so for us the task is often automatic—we understand without understanding how we understand.

Semantics was originally the philosophical discipline that dealt with the task of understanding how we understand, but, partly as a result of the advent of computers, the extraction of meaning from data or instructions has become a more practical concern.

So what does it mean “to understand.” This is perhaps a deep philosophical issue, but we don’t propose to address any deep or philosophical aspects of the issue. Instead, we will settle for an operational definition. Operational definitions usually turn out to be easier to work with than philosophical ones. We can say we understand the directions in a kit if we can use them to construct the system described and operate it. Analogously, a computer understands the instructions we give it if they cause it to carry out the assigned task.

The operational definition of understanding would read something like: “coded information can be said to be understood by the target system when the target system can use it to carry out the assigned task.” Thus, a computer that carries out the instructions of a program to perform an information processing task can be considered to have understood the instruction—the program. Similarly, when cellular machinery takes a segment of DNA, transcribes it to RNA, and uses the RNA template to manufacture the proteins specified by the DNA, it has “understood” the instructions coded in the DNA.

Such a definition is hardly bulletproof. If you tell your teenager to take out the garbage and she doesn’t, should you attribute the failure to lack of understanding? With computers, though, willful disobedience should be less of a problem, but I admit that I have often suspected otherwise.

Computer systems are often referred to as information technology, or IT, because information processing is now the principle function we wish them to serve. The older word, “computer,” is a legacy of the time when the main function computers carried out was mathematical computation.

The World Wide Web has given us potential access to an unprecedented wealth of information, but IT, in its present form, is limited in its capability to process and use that information. The paradigmatic IT function is extraction of data fitting specified criteria from a carefully structured database.

Most of the information now on the Web is not highly structured and was intended to be used by people, not machines. The wiring of our brains and the things we have learned permit us in many cases to understand the text, sounds, and imagery found in Web documents. There are always limits to that understanding: text or sounds in a language we don't understand will be opaque to us. Even documents written in our native tongue may be incomprehensible if understanding is dependent on specialized knowledge that we don't share.

The goal of the Semantic Web initiative is to improve machine understanding of the information on the Web by a combination of content side and processor side tools that identify the semantic content of information.

"The Semantic Web is an extension of the current web in which information is given well-defined meaning, better enabling computers and people to work in cooperation." (Berners-Lee, Hendler, and Lassila, 2001)

The *Semantic Web* provides a common framework that allows *data* to be shared and reused across application, enterprise, and community boundaries. It is a collaborative effort led by W3C with participation from a large number of researchers and industrial partners. It is based on the Resource Description Framework (RDF) (RDF Web page), which integrates a variety of applications using XML for syntax and URIs for naming. (Miller et al., 2005)

A couple of approaches to making data understandable to machines suggest themselves:
1) prepare all data in standard formats so that, in effect, the Web becomes a giant database and computer programs know in advance what kind of data they are dealing with, or 2) make computers at least as smart as humans at recognizing and interpreting data. Both of these strategies are beyond our capacity now and in the foreseeable future. The Semantic Web is a kind of compromise to implement aspects of each into an approach that can work right now. The fundamental idea, akin to 1) above, is to attach to each element of data some descriptive data, called metadata, that helps machines to understand its character and usage.

1.3 What is an Ontology?

Quite a variety of meanings have come to be associated with the word ontology, some of which are listed below. I first give a dictionary definition, followed by some of the specialized definitions being used in information technology:

- In its general meaning, ontology (pronounced ahn-TAH-luh-djee) is the study or concern about what kinds of things exist—what *entities* (Whatis.com, Entity) there are in the universe. It derives from the Greek onto (being) and logia (written or spoken discourse). It is a branch of metaphysics, the study of first principles or the essence of things.
- In information technology, an ontology is the working model of entities and interactions in some particular domain of knowledge or practices, such as electronic commerce or "the activity of planning." (Whatis.com, Word of the Day)
- Ontology: a vocabulary of terms and the precise relationships between them. (Dean 2002)
- An ontology is a controlled, hierarchical vocabulary for describing a knowledge system – *Magpie Automated Genomics Project* (Sensen).
- An ontology is a specification of a conceptualization. (Gruber)

If these definitions make everything crystal clear, the reader may feel free to skip to the next section. There is a certain irony in the fact that this word, which denotes some kinds of creations intended to facilitate understanding (by machines), is not so easy for us, as humans, to understand. As usually happens when we are trying to describe something new to our experience, we can't really understand it without some examples and operational definitions.

A few examples of ontological descriptions in the Defense Advanced Research Projects Agency (DARPA) Agent Markup Language + Ontology Inference Layer (DAML+OIL) ontology language will be given below to illustrate some of the usage. In DAML, everything is either an object or a data type value (Connolly et al., 2001). The following statement defines (actually it just labels it—the definition comes from the association of additional classes and properties with the class) the Weather Observation Class of objects:

```
<daml:Class rdf:ID="Weather Observation">
```

The structure of the ontology comes from the logical relations between the between the objects of the ontology. One of the basic logical relations is the subclass relationship:

```
<daml:Class rdf:ID="Precipitation">

<rdfs:subClassOf rdf:resource="# Observed Weather "/>

</daml:Class>
```

The above asserts the existence of the class Precipitation, and that Precipitation is a sub class of Observed Weather.

DAML+OIL also has implementations of many other familiar set manipulations, including complementation, disjunction (the classes of males and females, for example, would be disjoint), and disjoint union. For example, it would be possible to specify rain as the intersection of the precipitation and liquid water classes. Other facilities specify properties of classes and permit

definition of the range and domain of relations. Still other facilities support the specification of properties of a class. Taken together, these structures make it possible for machines to do a certain logical deductions, for example, the classic Aristotelian syllogism:

Socrates is a man.

All men are mortal.

Therefore: Socrates is mortal.

More in the spirit of the fragment above, we might suppose that our ontology defined rain as a subclass of precipitation. If we suppose further that the weather observation reported rain, then a query to the system asking for any precipitation report would retrieve the rain, even though rain was not explicitly mentioned in the query.

An example of an ontology, with detailed notes and explanations, is available in Connolly et al. 2001.

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2. The Gridded Met Database (GMDB)

2.1 Database

The GMDB contains meteorological information derived from the forecast grids of mesoscale meteorological models. A typical grids may consist of 51 by 51 grid points spaced 15 km or less apart, with "43 logarithmically spaced levels in the vertical extending to approximately 60,000 ft mean sea level (MSL). [The] models forecast the basic weather parameters which are post-processed to derive … a total of 53 parameters." (Raby, 2004)

This database contains output forecast files produced by the Battlescale Forecast Model (BFM) and the Fifth Generation Penn State/National Center for Atmospheric Research (NCAR) Mesoscale Model (MM5), or, more generally, any similar mesoscale model. The BFM provides 24-h forecasts at 3-h intervals over a 500 by 500 km grid of 51 by 51 grid points spaced horizontally 10 km apart and at 16 logarithmically spaced levels in the vertical extending to approximately 38,000 ft MSL. The MM5 provides 48-h forecasts at 3-h intervals over a 750 by 750 km grid of 51 by 51 grid points spaced horizontally 15 km apart and at 43 logarithmically spaced levels in the vertical extending to approximately 60,000 ft MSL. These models forecast the basic weather parameters for a total of 53 parameters. The BFM assimilates local observations and balloon measurements during initialization and incorporates the MM5 forecast for lateral boundary conditions and adjustments in the out-forecast periods. The MM5 version is derived by interpolating between grid points of the 45-km MM5 run, which is initialized with surface observations, meteorological buoy data, balloon measurements, dropsondes (when

available), pilot reports, satellite cloud-drift derived winds, and sea surface winds from satellite data. The 45-km MM5 uses the larger scale Global Forecast System (GFS) for adjustments and lateral boundary conditions (from the GMDB metadata file).

2.2 Applications

The information in the GMDB is the atmospheric substrate on which the Integrated Weather Effects Decision Aid (IWEDA) operates. The IWEDA contains a large number of rules that codify the effect of weather on Army systems. If the value of a weather parameter (stored in the GMDB) is in the yellow or red zone for a given system, the rule encoding the system sensitivity to that parameter "fires," and that weather impact can be output in several forms, including maps.

Major elements of the IWEDA, thus, include the system rule base, which encodes system weather sensitivities; the GMDB, which store the environmental data against which the rules are evaluated; and the inference engine, which performs the evaluations.

The parameters encoded in the present GMDB are far from being a complete set of those meterological parameters affecting military systems, however, so an additional motivation for developing an ontology of this type is the hope that it will provide a convenient tool for helping generate the additional derived parameters, which will be necessary for implementing a more comprehensive IWEDA.

2.2 GMDB Metadata

A metadata file of the GMDB and its parameters has been prepared by Leslie Johnson (2003) and is included as an appendix to this report, since it is the template from which the ontology was extracted. The ontology contains the same basic parameters, but the organization is somewhat different. Two types of changes have been made: firstly, some parameters that were listed as attributes in the metadata table have been promoted to entities, and secondly, additional structure and relationships reflecting the physics and meteorology have been introduced.

The promotions to entity were made in order to bring the semantics into line with the usual usage in physics and meteorology and to more accurately capture the meanings of the terms. For example, in the metadata table, air temperature is shown as an attribute of potential air temperature, but this has the physics backwards. Temperature is a more fundamental concept than potential temperature and is needed in its definition.

The additional structure added just reflects the additional capability of the ontology. An ontology can represent much richer relationships between concepts than a simple metadata table. It is this additional structure which is expected to give the ontology more capability in search and information representation.

3. Existing Ontologies

Ontologies of varying size, scope, and detail have been devised in a number of knowledge domains. Because the Army and the World Wide Web Consortium (W3C) currently focus on the Ontology Web Language (OWL), the examples used will be in OWL.

The first example (figure 1) is a very simple one created by the author to illustrate some aspects of the ontology editor being used, and some principles of ontology construction:

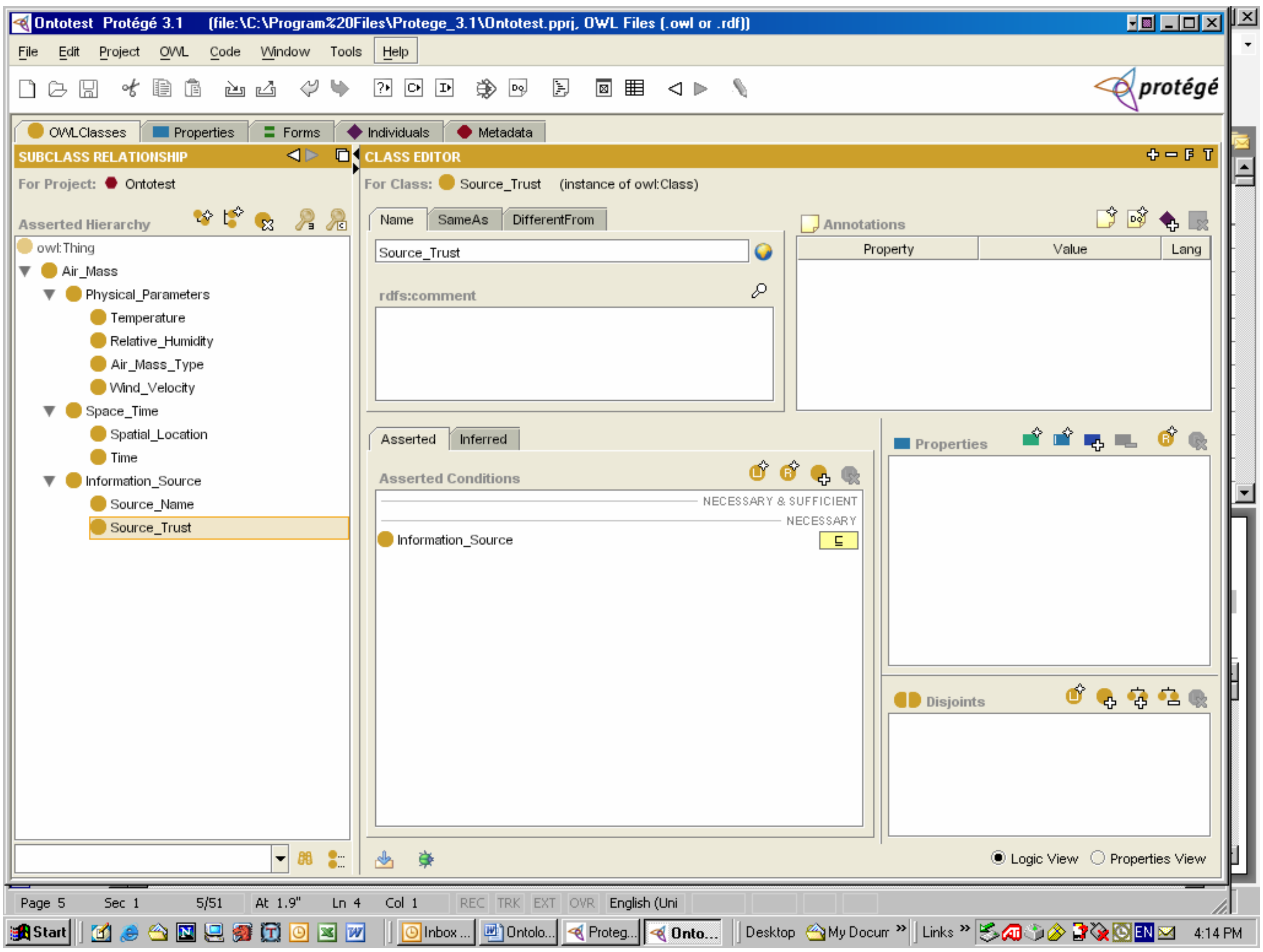

Figure 1. Graphic depiction of a simple OWL ontology.

4. Designing the GMDB Ontology

4.1 Introduction

Creating an ontology is an iterative process. Currently, I am on the third version of the GMDB ontology, and I already have lots of ideas for things that could be done differently and, ideally, better in a future version.

In creating any ontology, the most important issue is definition of the domain of discourse, that is, deciding what kinds of concepts and relationships are going to be modeled in the ontology. In the case of the GMDB, the overall structure and the basic concepts are given.

A second question is the choice of ontology tools and languages to use. The first two versions of the GMDB were written in OWL, but the third has been constructed in Protégé 3.1. All versions were constructed using the Protégé tools. Among the advantages of Protégé are its convenient graphical interface, relatively powerful syntax, and the fact that it's free.

Finally, there are a number of choices to be made in the modes of data representation. The primary objects in the ontology are the classes and their attributes. The choice of what is to be a class and what is to be an attribute is not necessarily clear cut. The atmospheric temperature parameter, for example, could be considered to be a class, with attributes that include not only its definition and the units in which it is measured, but also the time and location of the measurement. Alternatively, the air parcel could be considered to be the basic entity, with temperature as just one of its attributes.

It eventually became clear to me that the most straightforward way of creating an ontology from the metadata file, a simple entity-to-entity mapping, would not be practical or useful. This is due on one hand to certain peculiarities in the metadata file and on the other to the inherent limitations of the simple metadata paradigm.

The first type of problem shows up in the fact that not all of the 63 meteorological parameters found in the GMDB are represented as entities in the GMDB metadata file. For reasons that are not clear to me, many are represented as attributes. I didn't consider it desirable to imitate that practice in the ontology, so each parameter has been promoted to entity status in the ontology.

As an example of the second type of obstacle, there is no hierarchy among entities in the GMDB. Hierarchy is one of the simplest and most useful types of relationship representable in an ontology, so I created a hierarchy by grouping closely related parameters (see figures 2 and 3).

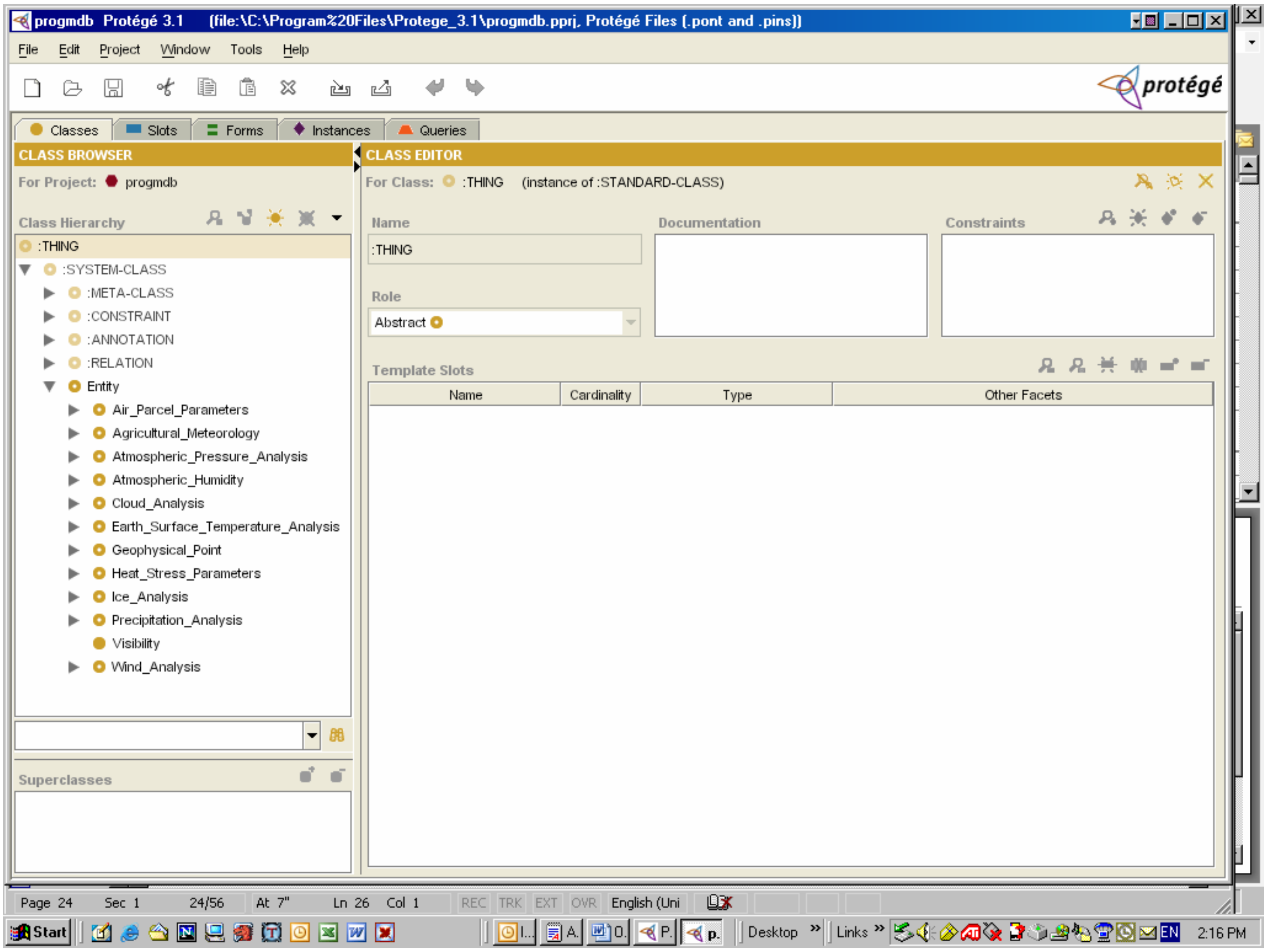

Figure 2. Graphic of the top level of the GMDB ontology.

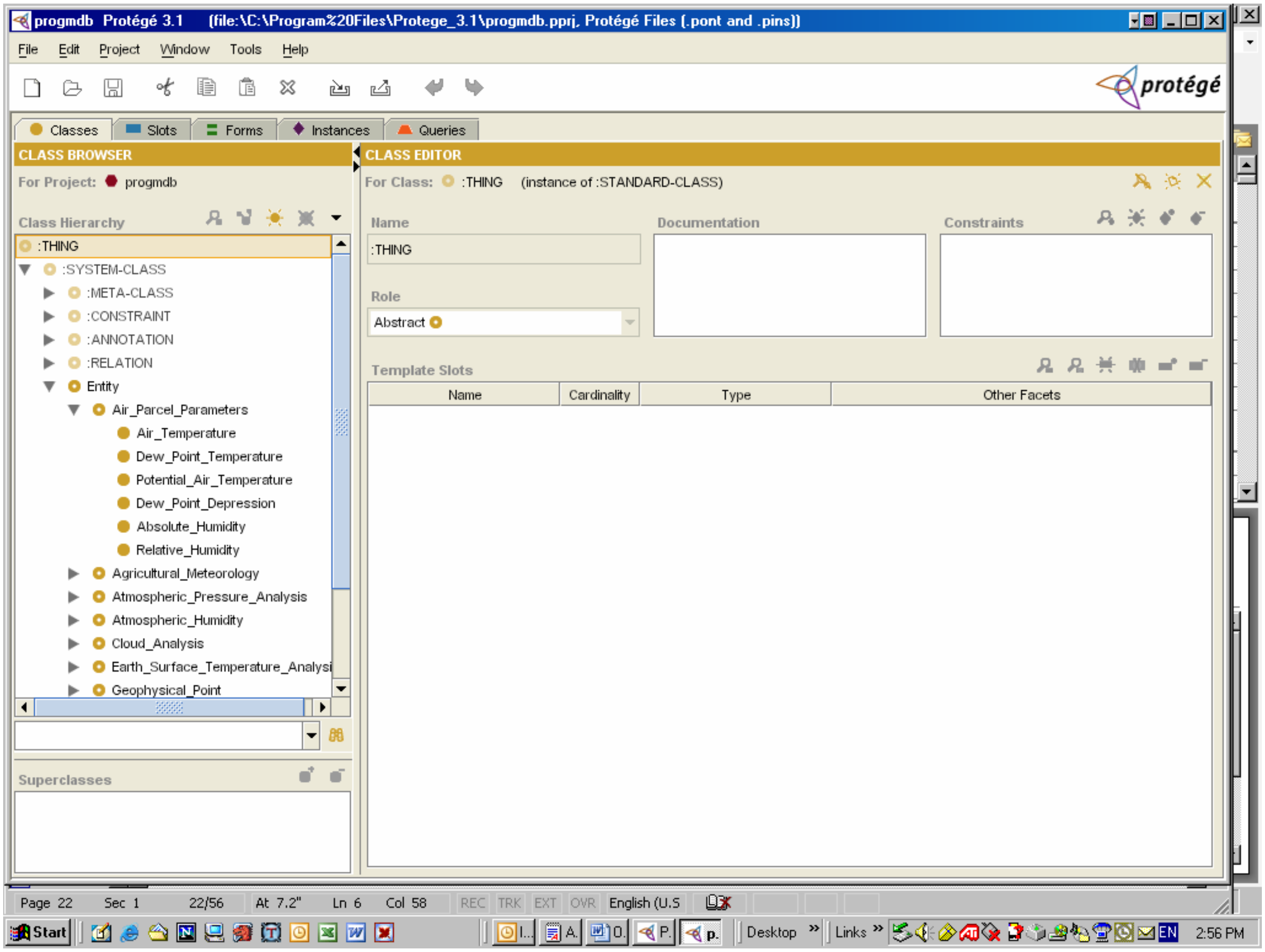

Figure 3. Graphic showing the base level parameters of the Air Parcel group.

4.2 Capturing the Essentials

The ultimate value of an ontology depends on its ability to serve the needs of the Semantic Web. To do that, it needs to include all the crucial vocabulary relevant to its domain of description. It should also know the most important relationships between the terms of its vocabulary.

The most fundamental meteorological entities are the wind, temperature, and water vapor at each point in space and time. Liquid water, snow, other particulates, and chemical contaminants are also important in many situations. These entities are fundamental, because they are the ones that enter into the dynamical equations and because they are usually the entities from which other weather related quantities are derived. A fundamental role is also played by some entities properly external to the atmosphere itself: the land or water surface beneath the atmosphere and the solar radiation incident upon the atmosphere.

Frequently these fundamental atmospheric properties are the ones that affect military and Soldier systems: wind, temperature, fog (liquid water in the atmosphere), rain, snow, and so on. In many cases, though, the effects are best understood in terms of derived notions: icing effects on aircraft, electro-optical (EO), and acoustic propagation; and atmospheric drag on artillery on projectiles, for example.

Most of the fundamental atmospheric entities and many derived ones are currently stored in the GMDB. There is a need to incorporate many other derived attributes, however. There are literally hundreds of documented atmospheric factors affecting military systems that are not currently incorporated into the GMDB (Szymber, 2006).

4.3 Encoding Attributes in the Ontology

Several kinds of attributes are associated with the entities in the GMDB. Some, like entity name, are shared by all the entities. Others, like the numerical range of allowed values, are usually unique to given entity. Still others, like the units of measurement for a numerical entity, are often shared by several related entities. All of these need to be represented in the ontology.

5. Status and Concerns

5.1 Future Work Required

An ontology is a tool. Of and by itself, it is as useless as a screwdriver without screws and things needing to be fastened together. The substrate on which an ontology needs to work is data with metadata markup. The third leg of this stool is a reasoning engine to make deductions about the data by making use of the ontology. Reasoning engines exist and are fairly sophisticated, and a few ontologies have now been created, but most stores of environmental data have yet to receive metadata markup. The latter is changing, though. The use of metadata markup is already widely recognized and is a cardinal feature of future defense information systems.

5.2 Marking Up All the Weather

If the Semantic Web is going to make all the weather information available, then all the weather information will need some semantic tagging attached to it. This ultimately depends on the suppliers of such data providing the markup, but in the interim, an option is available. If any particular set of weather data is needed, it should be possible to write programs to properly mark it up, provided the proper semantic categories exist or can be created in your weather ontology. Of course, one loses some or much of the advantage of semantic processing if one needs to create a preprocessor to put in the semantic markup, but once the preprocessor has been created, the data should become available in semantic format for other and future uses.

5.3 Relation to the DIB/NCES

The Distributed Common Ground System (DCGS) Integration Backbone (DIB), together with Net-Centric Enterprise Services (NCES), are envisioned as the master information management tool for networking future military operations. The goal is to be able to share tactical and related information efficiently and securely. Figure 4 and its caption are quoted from a Chairman of the Joint Chiefs of Staff Instruction (2005):

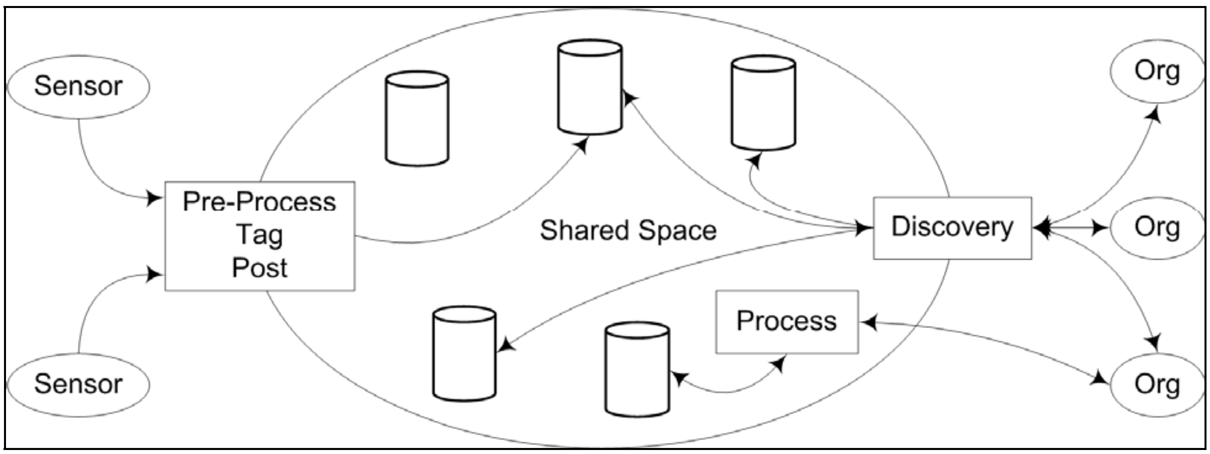

Figure 4. OV-1 To-Be (Notional).

NOTE: This is figure is identified as figure A-3 in the source document (Chairman of the Joint Chiefs of Staff Instruction, 2005).

A systems view of figure 4 demonstrates the DCGS as a tactical shared space. Sensors interface with DCGS through a composable and standards-based set of services in the DIB and NCES. Tactical organizations access the shared space through the same set of services. NCES links the tactical shared space to more accessible shared spaces, such as those available on Intelink or stored in a Department of Defense (DoD) Intelligence Information System (DoDIIS) Regional Service Center (RSC), the National Geospatial-Intelligence Agency (NGA) National Data Center (NDC), or the Regional Signals Intelligence Operations Center (RSOC). External organizations unable to interface directly with DCGS gain access from another shared space via NCES.

The DIB/NCES is supposed to provide the utilities to manage the flow of information to and from sensors, users, and others. One of the facilities it is expected to provide is a metadata dictionary. Incoming data is expected to be marked up with geospatial metadata indicating its nature, authentication, security level, and geospatial characteristics. The metadata dictionary is a first-level Semantic Web appliance, but it apparently it lacks the structure to support the full-fledged reasoning capabilities that an ontology could, in principle, supply.

Without that capability, interoperability will probably still need to be built largely by hand on a case-by-case basis; though, of course, the metadata dictionary will be a useful guide. Full machine-to-machine communication should still require a lot of customization.

A future version could potentially incorporate some of the additional capability of full ontologies. In addition, the existence of a metadata dictionary should facilitate the construction of ontologies in much the same way the GMDB metadata "dictionary" in the appendix has facilitated the construction of the prototype GMDB ontology.

5.4 The Future

Some of the power and potential of the future Web can be grasped in the program Google Earth. At present, Google Earth combines satellite imagery of the entire Earth with a geographic database of roads, cities, restaurants, stores, and much else with a fascinating visual interface. Starting from an overview of the globe, one can scan down to see details of mountains, rivers, and cities. For many locations, the imagery is detailed enough to recognize individual houses and cars. The representation is three-dimensional—one can do fly-throughs, rotate around a focus of interest (try Mount Fuji, for example), or move higher up for an overview.

At some point, future military planners should have access to a glorified, real-time or near real-time version of this—a version that incorporates weather, terrain, disposition of forces, and geographically relevant detailed intelligence. Most of the pieces necessary to implement this vision already exist. One of the most crucial pieces, though, is very incomplete—marked up data and the kind of ontological tools needed for machine interpretation of it.

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Appendix. GMDB Metadata

(Prepared by Leslie Johnson.)

Gridded Meteorological Database – GMDB

Metadata Sections:

Identification Information
Entity and Attribute Information
Distribution Information
Metadata Reference Information

Identification Information:
Citation:
Citation Information:
Originator: ARL/BED
Publication Date: 20010523
Title: Gridded Meteorological Database - GMDB
Online Linkage:
MEL Custom Order Form: **<URL:http://mel.dmso.mil/mel-bin/order?site=arla&ofile=gmdb1.meta&action=order>**
Description:
Abstract:
GMDB stands for Gridded Meteorological Database. This database contains output forecast files produced by the Battlescale Forecast Model (BFM) and the Fifth Generation Penn State/NCAR Mesoscale Model (MM5). The BFM provides 24 hour forecasts at 3-hour intervals over a 500X500 KM grid of 51X51 gridpoints spaced horizontally 10 KM apart and at 16 logarithmically spaced levels in the vertical extending to approximately 38,000 feet MSL. The MM5 provides 48 hour forecasts at 3-hour intervals over a 750X750 KM grid of 51X51 gridpoints spaced horizontally 15KM apart and at 43 logarithmically spaced levels in the vertical extending to approximately 60,000 feet MSL. These models forecast the basic weather parameters for a total of 53 parameters. The BFM assimilates local observations and balloon measurements during initialization and incorporates the MM5 forecast for lateral boundary conditions and adjustments in the out-forecast periods. The MM5 is derived by interpolating between grid point of the 45 KM MM5 run which is initialized with surface observations, meteorological buoy data, balloon measurements, dropsondes (when available), Pilot Reports, satellite cloud drift derived winds, and sea surface winds from satellite data. The 45 KM MM5 uses the larger scale Global Forecast System (GFS) for adjustments and lateral boundary conditions.
Purpose:
The primary purpose of this data set is to provide meteorological data that is generated during a typical BFM run.
Time Period of Content:
Time Period Information:

Range of Dates/Times:
Beginning Date: 20010925
Beginning Time: 00000000Z
Ending Date: 20010926
Ending Time: 00000000Z
Currentness Reference: Time of model run.
Status:
Progress: Complete
Maintenance and Update Frequency: As needed
Spatial Domain:
Bounding Coordinates:
West Bounding Coordinate: -180.0000
East Bounding Coordinate: 180.0000
North Bounding Coordinate: 90.0000
South Bounding Coordinate: -90.0000
Keywords:
Theme:
Theme Keyword Thesaurus: MEL_Scientific-Engineering_Field_Thesaurus
Theme Keyword: Atmosphere
Theme Keyword: Meteorology
Place:
Place Keyword Thesaurus: MEL_Location_Thesaurus
Place Keyword: Global
Stratum:
Stratum Keyword Thesaurus: MEL_Environmental_Domain_Thesaurus
Stratum Keyword: Air
Stratum Keyword: Air/Land Interface
Temporal:
Temporal Keyword Thesaurus: MEL_Temporal_Coverage_Thesaurus
Temporal Keyword: Real-time data
Access Constraints: None
Use Constraints: None
Point of Contact:
Contact Information:
Contact Organization Primary:
Contact Organization: Army Research Laboratory
Contact Position: ARL MEL Administrator
Contact Address:
Address Type: mailing and physical address
Address: White Sands Missile Range
City: White Sands
State or Province: NM
Postal Code: 88002
Country: US
Contact Voice Telephone: (505) 678-2987
Contact Electronic Mail Address: **mbustill@arl.army.mil**

Security Information:
Security Classification System:
Department of Defense Trusted Computer Systems Evaluation Criteria CSC-STD-001-83
Security Classification: Unclassified
Security Handling Description: None

Entity and Attribute Information:
Detailed Description:
Entity Type:
Entity Type Label: AIR-TEMPERATURE-POTENTIAL
Entity Type Definition:
An estimate of the measure of heat and psychrometric parameters in the air.
Entity Type Definition Source: DDDS
Attribute:
Attribute Label: AIR-TEMPERATURE-POTENTIAL air temperature
Attribute Definition: The temperature of the air.
Attribute Definition Source: ARL
Attribute Domain Values:
Range Domain:
Range Domain Minimum: 163
Range Domain Maximum: 336
Attribute Units of Measure: DEGREES-KELVIN
Attribute:
Attribute Label: AIR-TEMPERATURE-POTENTIAL dew point temperature
Attribute Definition:
The estimated temperature to which a given parcel of air must be cooled at constant pressure and water vapor content in order for saturation to occur. Any further cooling usually results in the formation of dew or frost.
Attribute Definition Source: ARL
Attribute Domain Values:
Range Domain:
Range Domain Minimum: 240
Range Domain Maximum: 312
Attribute Units of Measure: DEGREES-KELVIN
Attribute:
Attribute Label: AIR-TEMPERATURE-POTENTIAL potential air temperature
Attribute Definition:
The temperature that a dry air parcel would have if transported adiabatically from its ambient temperature and pressure to 1000 mb (milibars).
Attribute Definition Source: ARL
Attribute Domain Values:
Range Domain:
Range Domain Minimum: 240
Range Domain Maximum: 330
Attribute Units of Measure: DEGREES-KELVIN
Attribute:

Attribute Label: AIR-TEMPERATURE-POTENTIAL dewpoint depression
Attribute Definition:
The difference between the air temperature and the dew point temperature.
Attribute Definition Source: ARL
Attribute Domain Values:
Range Domain:
Range Domain Minimum: 0
Range Domain Maximum: 39
Attribute Units of Measure: DEGREES-KELVIN
Attribute:
Attribute Label: AIR-TEMPERATURE-POTENTIAL relative humidity
Attribute Definition:
The amount of water vapor (vapor pressure) in a given parcel of air divided by the maximum amount of water vapor the parcel of air could contain at a given temperature (saturation vapor pressure) before it would begin to condense into water droplets.
Attribute Definition Source: ARL
Attribute Domain Values:
Range Domain:
Range Domain Minimum: 0
Range Domain Maximum: 100
Attribute Units of Measure: PERCENT
Attribute:
Attribute Label: AIR-TEMPERATURE-POTENTIAL absolute humidity
Attribute Definition:
The ratio of the mass of water vapor to the volume occupied by a mixture of water vapor and dry air.
Attribute Definition Source: ARL
Attribute Domain Values:
Range Domain:
Range Domain Minimum: 0.12
Range Domain Maximum: 51.1
Attribute Units of Measure: GM/M3
Detailed Description:
Entity Type:
Entity Type Label: CLOUD-ANALYSIS
Entity Type Definition: An estimate of cloud coverage conditions.
Entity Type Definition Source: ARL
Attribute:
Attribute Label: CLOUD-ANALYSIS cloud cover at height
Attribute Definition:
The fraction of the celestial dome which is covered by clouds at a specified height. Range is 0-10. 0-8 indicate eighths of coverage, and 10 is reserved for fog.
Attribute Definition Source: ARL
Attribute Domain Values:
Range Domain:
Range Domain Minimum: 0

Range Domain Maximum: 10
Attribute Units of Measure: CODE
Attribute:
Attribute Label: CLOUD-ANALYSIS cloud ceiling height
Attribute Definition:
The height of the cloud base for the lowest broken or overcast cloud layer.
Attribute Definition Source: ARL
Attribute Domain Values:
Range Domain:
Range Domain Minimum: 0
Range Domain Maximum: 12200
Attribute Units of Measure: METERS
Attribute:
Attribute Label: CLOUD-ANALYSIS cloud liquid water
Attribute Definition:
The mass of liquid water (milligrams) within a column of the atmosphere subtended by a unit of area.
Attribute Definition Source: ARL
Attribute Domain Values:
Range Domain:
Range Domain Minimum: 0
Range Domain Maximum: 0.000962
Attribute Units of Measure: KG/KG
Attribute:
Attribute Label: CLOUD-ANALYSIS total cloud cover
Attribute Definition:
The fraction of the celestial dome which is covered by clouds regardless of level. Range is 0-10. 0-8 indicate eighths of coverage, and 10 is reserved for fog.
Attribute Definition Source: ARL
Attribute Domain Values:
Range Domain:
Range Domain Minimum: 0
Range Domain Maximum: 10
Attribute Units of Measure: CODE
Attribute:
Attribute Label: CLOUD-ANALYSIS low cloud type
Attribute Definition:
The type of low clouds present. Range is 0-3 as follows: 0=None 1=Stratus 2=Stratocumulus 3=Cumulus
Attribute Definition Source: ARL
Attribute Domain Values:
Range Domain:
Range Domain Minimum: 0
Range Domain Maximum: 3
Attribute Units of Measure: CODE
Attribute:

Attribute Label: CLOUD-ANALYSIS middle cloud type
Attribute Definition:
The type of middle clouds present. Range is 0-3 as follows: 0=None 1=Altostratus 2=Altocumulus 3=Altocumulus castellanus
Attribute Definition Source: ARL
Attribute Domain Values:
Range Domain:
Range Domain Minimum: 0
Range Domain Maximum: 3
Attribute Units of Measure: CODE
Attribute:
Attribute Label: CLOUD-ANALYSIS high cloud type
Attribute Definition:
The type of high clouds present. Range is 0-3 as follows: 0=None 1=Cirrus 2=Cirrostratus 3=Cirrocumulus
Attribute Definition Source: ARL
Attribute Domain Values:
Range Domain:
Range Domain Minimum: 0
Range Domain Maximum: 3
Attribute Units of Measure: CODE
Attribute:
Attribute Label: CLOUD-ANALYSIS low cloud amount
Attribute Definition:
The amount of low clouds present. Range is 0-10. 0-8 indicate eighths of coverage, and 10 is reserved for fog.
Attribute Definition Source: ARL
Attribute Domain Values:
Range Domain:
Range Domain Minimum: 0
Range Domain Maximum: 10
Attribute Units of Measure: eighths
Attribute:
Attribute Label: CLOUD-ANALYSIS middle cloud amount
Attribute Definition:
The amount of middle clouds present. Range is 0-8. 0-8 indicate eighths of coverage.
Attribute Definition Source: ARL
Attribute Domain Values:
Range Domain:
Range Domain Minimum: 0
Range Domain Maximum: 8
Attribute Units of Measure: eighths
Attribute:
Attribute Label: CLOUD-ANALYSIS high cloud amount
Attribute Definition:
The amount of high clouds present. Range is 0-8. 0-8 indicate eighths of coverage.

Attribute Definition Source: ARL
Attribute Domain Values:
Range Domain:
Range Domain Minimum: 0
Range Domain Maximum: 8
Attribute Units of Measure: eighths
Attribute:
Attribute Label: CLOUD-ANALYSIS low cloud base height
Attribute Definition: The height of the base of forecast low clouds
Attribute Definition Source: ARL
Attribute Domain Values:
Range Domain:
Range Domain Minimum: 0
Range Domain Maximum: 2112
Attribute Units of Measure: METERS
Attribute:
Attribute Label: CLOUD-ANALYSIS middle cloud base height
Attribute Definition: The height of the base of forecast middle clouds
Attribute Definition Source: ARL
Attribute Domain Values:
Range Domain:
Range Domain Minimum: 2112
Range Domain Maximum: 4201
Attribute Units of Measure: METERS
Attribute:
Attribute Label: CLOUD-ANALYSIS high cloud base height
Attribute Definition: The height of the base of forecast high clouds
Attribute Definition Source: ARL
Attribute Domain Values:
Range Domain:
Range Domain Minimum: 4201
Range Domain Maximum: 9999
Attribute Units of Measure: METERS
Attribute:
Attribute Label: CLOUD-ANALYSIS inversion height
Attribute Definition: The estimated height of the inversion layer.
Attribute Definition Source: ARL
Attribute Domain Values:
Range Domain:
Range Domain Minimum: 0
Range Domain Maximum: 9999
Attribute Units of Measure: METERS
Detailed Description:
Entity Type:
Entity Type Label: EARTH-SURFACE-TEMPERATURE-ANALYSIS
Entity Type Definition: An estimate of the temperature of the surface of the earth.

Entity Type Definition Source: ARL
Attribute:
Attribute Label: EARTH-SURFACE-TEMPERATURE-ANALYSIS wet bulb globe temperature
Attribute Definition:
A parameter combining the effects of humidity, temperature and sun radiation which is used to forecast the heat stress potential.
Attribute Definition Source: ARL
Attribute Domain Values:
Range Domain:
Range Domain Minimum: 200.0
Range Domain Maximum: 350.0
Attribute Units of Measure: DEGREES-KELVIN
Detailed Description:
Entity Type:
Entity Type Label: HEAT-STRESS-PARAMETERS
Entity Type Definition: Parameters related to heat stress on active soldiers.
Entity Type Definition Source: ARL
Attribute:
Attribute Label: HEAT-STRESS-PARAMETERS heat injury percent
Attribute Definition:
The forecast percentage of personnel expected to suffer heat related injury.
Attribute Definition Source: ARL
Attribute Domain Values:
Range Domain:
Range Domain Minimum: 0
Range Domain Maximum: 100
Attribute Units of Measure: PERCENT
Attribute:
Attribute Label: HEAT-STRESS-PARAMETERS work rest cycle
Attribute Definition: The forecast duration of work followed by rest cycles.
Attribute Definition Source: ARL
Attribute Domain Values:
Range Domain:
Range Domain Minimum: 0
Range Domain Maximum: 90
Attribute Units of Measure: MINUTES
Attribute:
Attribute Label: HEAT-STRESS-PARAMETERS H20 rations
Attribute Definition: The forecast amount of water required for soldier hydration.
Attribute Definition Source: ARL
Attribute Domain Values:
Range Domain:
Range Domain Minimum: 0
Range Domain Maximum: 6
Attribute Units of Measure: CANTEENS/HOUR

Attribute:
Attribute Label: HEAT-STRESS-PARAMETERS maximum work time
Attribute Definition:
The forecast maximum amount of time work can be safely performed before onset of heat injury.
Attribute Definition Source: ARL
Attribute Domain Values:
Range Domain:
Range Domain Minimum: 0
Range Domain Maximum: 450
Attribute Units of Measure: MINUTES
Attribute:
Attribute Label: HEAT-STRESS-PARAMETERS soil temperature
Attribute Definition: The forecast soil temperature.
Attribute Definition Source: ARL
Attribute Domain Values:
Range Domain:
Range Domain Minimum: 200
Range Domain Maximum: 400
Attribute Units of Measure: DEGREES-KELVIN
Detailed Description:
Entity Type:
Entity Type Label: ATMOSPHERIC-PRESSURE-ANALYSIS
Entity Type Definition: An estimate of characteristics of air pressure.
Entity Type Definition Source: ARL
Attribute:
Attribute Label: ATMOSPHERIC-PRESSURE-ANALYSIS pressure
Attribute Definition: Total pressure present
Attribute Definition Source: ARL
Attribute Domain Values:
Range Domain:
Range Domain Minimum: -400
Range Domain Maximum: 99999
Attribute Units of Measure: PA
Attribute:
Attribute Label: ATMOSPHERIC-PRESSURE-ANALYSIS Mean sea level pressure
Attribute Definition:
The forecast atmospheric pressure at mean sea level, usually determined from the observed station pressure.
Attribute Definition Source: ARL
Attribute Domain Values:
Range Domain:
Range Domain Minimum: 900
Range Domain Maximum: 1050
Attribute Units of Measure: millibars
Attribute:
Attribute Label: ATMOSPHERIC-PRESSURE-ANALYSIS pressure altitude

Attribute Definition:
The altitude in standard atmosphere at which a given pressure will be observed. It is the indicated altitude of a pressure altimeter at an altitude setting of 29.92 inches of mercury, and is therefore the indicated altitude above the 29.92 constant pressure surface.
Attribute Definition Source: ARL
Attribute Domain Values:
Range Domain:
Range Domain Minimum: -600
Range Domain Maximum: 99999
Attribute Units of Measure: feet
Attribute:
Attribute Label: ATMOSPHERIC-PRESSURE-ANALYSIS density altitude
Attribute Definition:
The altitude at which a given denisty is found in the standard atmosphere.
Attribute Definition Source: ARL
Attribute Domain Values:
Range Domain:
Range Domain Minimum: -4444
Range Domain Maximum: 62000
Attribute Units of Measure: feet
Attribute:
Attribute Label: ATMOSPHERIC-PRESSURE-ANALYSIS perturbation pressure
Attribute Definition:
The amount of the pressure variation from the mean pressure caused by the normal variation in atmospheric pressure from one atmospheric column to another.
Attribute Definition Source: ARL
Attribute Domain Values:
Range Domain:
Range Domain Minimum: -3000
Range Domain Maximum: 4500
Attribute Units of Measure: PA
Detailed Description:
Entity Type:
Entity Type Label: GEOPHYSICAL-POINT
Entity Type Definition:
A statistical analysis of historical geophysical data for a point.
Entity Type Definition Source: ARL
Attribute:
Attribute Label: GEOPHYSICAL-POINT geopotential height
Attribute Definition:
Aproximates the actual height of a pressure surface above mean sea-level in meters. For example, a geopotential height of 1500 is the number of meters above sea-level one would have to be to reach a pressure of 850mb.
Attribute Definition Source: ARL
Attribute Domain Values:
Range Domain:

Range Domain Minimum: -400
Range Domain Maximum: 30000
Attribute Units of Measure: METERS
Attribute:
Attribute Label: GEOPHYSICAL-POINT surface elevation
Attribute Definition:
The elevation above or below mean sea level of the surface of the earth.
Attribute Definition Source: ARL
Attribute Domain Values:
Range Domain:
Range Domain Minimum: -408
Range Domain Maximum: 8848
Attribute Units of Measure: METERS
Attribute:
Attribute Label: ATMOSPHERIC-PRESSURE-ANALYSIS altimeter setting
Attribute Definition:
The pressure value to which an aircraft altimeter scale is set so that it will indicate the altitude above mean sea level of an aircraft on the ground at the location for which the value was determined.
Attribute Definition Source: ARL
Attribute Domain Values:
Range Domain:
Range Domain Minimum: 25.69
Range Domain Maximum: 33.00
Attribute Units of Measure: INCHES HG
Detailed Description:
Entity Type:
Entity Type Label: ICE-ANALYSIS
Entity Type Definition:
The condition of ice derived from interpretation of ice observation(s)
Entity Type Definition Source: ARL
Attribute:
Attribute Label: ICE-ANALYSIS-FORECAST icing
Attribute Definition:
Parameter which forecasts the potential for accumulation of ice on aircraft external surfaces, propellers and engine inlets from freezing rain or flight through inclement weather. Range code values 0-8 as follows: 0= None 1= Trace 2=Light rime 3=Light clear 4=Light mixed 5=Moderate rime 6=Moderate clear 7=Moderate mixed 8=Severe clear
Attribute Definition Source: ARL
Attribute Domain Values:
Range Domain:
Range Domain Minimum: 0
Range Domain Maximum: 8
Attribute Units of Measure: CODE
Attribute:
Attribute Label: ICE-ANALYSIS-FORECAST fog

Attribute Definition:
A surface based cloud composed of either water droplets or ice crystals which restricts the visibility making it a hazard for aviation. Range code as follows: 0=No fog 1=Fog
Attribute Definition Source: ARL
Attribute Domain Values:
Range Domain:
Range Domain Minimum: 0
Range Domain Maximum: 1
Attribute Units of Measure: CODE
Detailed Description:
Entity Type:
Entity Type Label: PRECIPITATION-ANALYSIS
Entity Type Definition: An estimate of characteristics of precipitation.
Entity Type Definition Source: ARL
Attribute:
Attribute Label: PRECIPITATION-ANALYSIS precipitation type
Attribute Definition:
The type and intensity of precipitation forecast. Range code 0-4 as follows: 0= None 1=Rain 2=Snow 3=Freezing rain 4=Mixed precipitation
Attribute Definition Source: ARL
Attribute Domain Values:
Range Domain:
Range Domain Minimum: 0
Range Domain Maximum: 4
Attribute Units of Measure: CODE
Attribute:
Attribute Label: PRECIPITATION-ANALYSIS precipitation rate
Attribute Definition: Rate of precipitation falling.
Attribute Definition Source: ARL
Attribute Domain Values:
Range Domain:
Range Domain Minimum: 0
Range Domain Maximum: 300
Attribute Units of Measure: MM/HR
Attribute:
Attribute Label: PRECIPITATION-ANALYSIS accumulated precipitation
Attribute Definition: Precipitation accumulated over the entire forecast period.
Attribute Definition Source: ARL
Attribute Domain Values:
Range Domain:
Range Domain Minimum: 0
Range Domain Maximum: 6000
Attribute Units of Measure: MILLIMETERS
Attribute:
Attribute Label: PRECIPITATION-ANALYSIS thunderstorm probability
Attribute Definition: Probabilty of thunderstorm activity.

Attribute Definition Source: ARL
Attribute Domain Values:
Range Domain:
Range Domain Minimum: 0
Range Domain Maximum: 100
Attribute Units of Measure: PERCENT
Attribute:
Attribute Label: PRECIPITATION-ANALYSIS severe weather
Attribute Definition:
The forecast occurrence or non-occurrence of severe thunderstorms. Range code as follows: 0=No severe thunderstorms, 1=Severe thunderstorms
Attribute Definition Source: ARL
Attribute Domain Values:
Range Domain:
Range Domain Minimum: 0
Range Domain Maximum: 1
Attribute Units of Measure: CODE
Attribute:
Attribute Label: PRECIPITATION-ANALYSIS pasquill stability
Attribute Definition:
Pasquill stability index. Range code 1-7 as follows: 1=Category A (very unstable) 2=Category B (unstable) 3=Category C (Slightly unstable) 4=Category D (Neutral) 5=Category E (Slightly stable) 6=Category F (Stable) 7=Category G (Very stable)
Attribute Definition Source: ARL
Attribute Domain Values:
Range Domain:
Range Domain Minimum: 1
Range Domain Maximum: 7
Attribute Units of Measure: CODE
Attribute:
Attribute Label: PRECIPITATION-ANALYSIS large scale precipitation
Attribute Definition: Amount of large scale precipitation present.
Attribute Definition Source: ARL
Attribute Domain Values:
Range Domain:
Range Domain Minimum: 0
Range Domain Maximum: 9999
Attribute Units of Measure: (KG/M*M)
Attribute:
Attribute Label: PRECIPITATION-ANALYSIS convective precipitation
Attribute Definition: Amount of convective precipitation present.
Attribute Definition Source: ARL
Attribute Domain Values:
Range Domain:
Range Domain Minimum: 0
Range Domain Maximum: 9999

Attribute Units of Measure: (KG/M*M)
Detailed Description:
Entity Type:
Entity Type Label: WIND-ANALYSIS
Entity Type Definition: An estimate of characteristics of the movement of air.
Entity Type Definition Source: ARL
Attribute:
Attribute Label: WIND-ANALYSIS wind speed
Attribute Definition: The current wind speed.
Attribute Definition Source: ARL
Attribute Domain Values:
Range Domain:
Range Domain Minimum: 0
Range Domain Maximum: 9999
Attribute Units of Measure: METERS/SECOND
Attribute:
Attribute Label: WIND-ANALYSIS wind direction
Attribute Definition: The current wind direction.
Attribute Definition Source: ARL
Attribute Domain Values:
Range Domain:
Range Domain Minimum: -9999
Range Domain Maximum: 9999
Attribute Units of Measure: DEGREES
Attribute:
Attribute Label: WIND-ANALYSIS wind u vector
Attribute Definition: The East-West component of the wind.
Attribute Definition Source: ARL
Attribute Domain Values:
Range Domain:
Range Domain Minimum: -100
Range Domain Maximum: 100
Attribute Units of Measure: METERS/SECOND
Attribute:
Attribute Label: WIND-ANALYSIS wind v vector
Attribute Definition: The North-South component of the wind.
Attribute Definition Source: ARL
Attribute Domain Values:
Range Domain:
Range Domain Minimum: -100
Range Domain Maximum: 100
Attribute Units of Measure: METERS/SECOND
Attribute:
Attribute Label: WIND-ANALYSIS wind chill temperature
Attribute Definition:
The wind chill index is the temperature the human body feels when the air temperature is

combined with the wind speed. The higher the wind speed the faster exposed areas of the body lose heat and the cooler the body feels.
Attribute Definition Source: ARL
Attribute Domain Values:
Range Domain:
Range Domain Minimum: 200
Range Domain Maximum: 280
Attribute Units of Measure: DEGREES KELVIN
Attribute:
Attribute Label: WIND-ANALYSIS wind gust speed
Attribute Definition:
The wind gust is the maximum wind speed forecast over a specified time period. When wind speeds are forecast and the peak wind speed during the forecast period is at least 10 knots more than the average wind speed, a wind gust is forecast.
Attribute Definition Source: ARL
Attribute Domain Values:
Range Domain:
Range Domain Minimum: 0
Range Domain Maximum: 150
Attribute Units of Measure: METERS/SECOND
Attribute:
Attribute Label: WIND-ANALYSIS visibility
Attribute Definition:
A forecast of the opacity of the atmosphere, and therefore, the greatest distance one can see prominent objects with normal eyesight.
Attribute Definition Source: ARL
Attribute Domain Values:
Range Domain:
Range Domain Minimum: 0
Range Domain Maximum: 45000
Attribute Units of Measure: METERS
Attribute:
Attribute Label: WIND-ANALYSIS turbulence
Attribute Definition:
Unstable motions in aircraft induced by atmospheric motions generated by large wind velocity or directional shears. Range code 0=3 as follows: 0=None 1=Light 2=Moderate 3=Severe
Attribute Definition Source: ARL
Attribute Domain Values:
Range Domain:
Range Domain Minimum: 0
Range Domain Maximum: 3
Attribute Units of Measure: CODE
Attribute:
Attribute Label: WIND-ANALYSIS illumination
Attribute Definition: The level of natural ambient light forecast.
Attribute Definition Source: ARL

Attribute Domain Values:
Range Domain:
Range Domain Minimum: 0
Range Domain Maximum: 99999999
Attribute Units of Measure: MILLILUX
Detailed Description:
Entity Type:
Entity Type Label: AGRICULTURAL-METEOROLOGY
Entity Type Definition:
Parameters dealing with foliage and land type having an impact on forecast data.
Entity Type Definition Source: ARL
Attribute:
Attribute Label: AGRICULTURAL-METEOROLOGY latent heat net flux
Attribute Definition:
The net result of the heat released or absorbed from the atmosphere as a result of the phase change of water. Values are three hour averages which are positive for evaporation, sublimation and melting. The values are negative for condensation and freezing.
Attribute Definition Source: ARL
Attribute Domain Values:
Range Domain:
Range Domain Minimum: -100
Range Domain Maximum: 600
Attribute Units of Measure: Watts/m2
Attribute:
Attribute Label: AGRICULTURAL-METEOROLOGY sensible heat net flux
Attribute Definition:
The net result of the flow of heat which can be directly sensed or measured as it flows from a hot object such as the earth's surface toward the cooler atmosphere. Values are three hour averages which are positive for heat flowing from the earth's surface into the atmosphere. The values are negative if the flow is reversed from the atmosphere towards the earth.
Attribute Definition Source: ARL
Attribute Domain Values:
Range Domain:
Range Domain Minimum: -100
Range Domain Maximum: 600
Attribute Units of Measure: Watts/m2
Attribute:
Attribute Label: AGRICULTURAL-METEOROLOGY friction velocity
Attribute Definition:
A reference wind velocity that represents the effect of wind stress on the ground. This velocity varies with the nature of the surface over which the wind is blowing and the magnitude of the wind.
Attribute Definition Source: ARL
Attribute Domain Values:
Range Domain:
Range Domain Minimum: 0

Range Domain Maximum: 2
Attribute Units of Measure: m/s
Attribute:
Attribute Label: AGRICULTURAL-METEOROLOGY specific humidity
Attribute Definition:
The ratio of the density of the water vapor to the density of the air, a mix of dry air and water vapor. It is expressed in kilograms per kilogram. The specific humidity of an air parcel remains constant unless water vapor is added to or taken from the parcel.
Attribute Definition Source: ARL
Attribute Domain Values:
Range Domain:
Range Domain Minimum: 0.00010
Range Domain Maximum: .050
Attribute Units of Measure: kg/kg
Attribute:
Attribute Label: AGRICULTURAL-METEOROLOGY air temperature (surface)
Attribute Definition: The temperature of the air measured at the two meter level.
Attribute Definition Source: ARL
Attribute Domain Values:
Range Domain:
Range Domain Minimum: 203
Range Domain Maximum: 333
Attribute Units of Measure: Degrees Kelvin
Attribute:
Attribute Label: AGRICULTURAL-METEOROLOGY albedo
Attribute Definition:
Three hour average of the surface albedo (reflectivity of the Earth's surface), which includes the effects of snowcover.
Attribute Definition Source: ARL
Attribute Domain Values:
Range Domain:
Range Domain Minimum: 0
Range Domain Maximum: 100
Attribute Units of Measure: Percent
Attribute:
Attribute Label: AGRICULTURAL-METEOROLOGY water equivalent to accumulated snow
Attribute Definition:
Depth of liquid water that would be obtained by melting a given depth of snow.
Attribute Definition Source: ARL
Attribute Domain Values:
Range Domain:
Range Domain Minimum: 0
Range Domain Maximum: 600
Attribute Units of Measure: Millimeters
Attribute:
Attribute Label: AGRICULTURAL-METEOROLOGY Land/Sea Mask

Attribute Definition:
A parameter which characterizes the surface category at the grid point as either being land or water. Range code: 0 = Sea, 1 = Land
Attribute Definition Source: ARL
Attribute Domain Values:
Range Domain:
Range Domain Minimum: 0
Range Domain Maximum: 1
Attribute Units of Measure: Code
Attribute:
Attribute Label: AGRICULTURAL-METEOROLOGY relative soil moisture
Attribute Definition:
Relative soil moisture is based on the relationship between the volumetric soil moisture, the wilting point soil moisture, and the maximum soil moisture or porosity all of which are soil type dependent.
Attribute Definition Source: ARL
Attribute Domain Values:
Range Domain:
Range Domain Minimum: 0
Range Domain Maximum: 1
Attribute Units of Measure: Unitless
Attribute:
Attribute Label: AGRICULTURAL-METEOROLOGY soil type
Attribute Definition:
Fixed file of codes indicating the type of soil at each grid point. Soil type is specified from the hybrid STATSGO/FAO database of NCAR. Wilting point and porosity are used to calculate relative soil moisture. Range Code As Follows: 1= Sand, 2=Loamy Sand, 3=Sandy Loam, 4=Silt Loam, 5=Silt, 6=Loam, 7=Sandy Clay Loam, 8=Silty Clay Loam, 9=Clay Loam, 10=Sandy Clay, 11=Silty Clay, 12=Clay, 13=Organic Materials, 14=Water, 15=Bedrock, 16=Other (Land/Ice)
Attribute Definition Source: ARL
Attribute Domain Values:
Range Domain:
Range Domain Minimum: 1
Range Domain Maximum: 16
Attribute Units of Measure: Code
Attribute:
Attribute Label: AGRICULTURAL-METEOROLOGY vegetation type
Attribute Definition:
The vegetation at each grid point is based on the thirty second NCAR/USGS database. Range Code As Follows: 1=Urban, 2=Dryland Cropland and Pasture, 3=Irrigated Cropland and Pasture, 4=Mixed Dryland/Irrigated Cropland and Pasture, 5=Cropland/Grassland Mosaic, 6=Cropland/Woodland Mosaic, 7=Grassland, 8=Shrubland, 9=Mixed Shrubland/Grassland, 10=Savanna, 11=Deciduous Broadleaf Forest, 12=Deciduous Needleleaf Forest, 13=Evergreen Broadleaf Forest, 14=Evergreen Needleleaf Forest, 15=Mixed Forest, 16=Water Bodies, 17=Herbaceous Wetland, 18=Wooded Wetland, 19=Barren or Sparsely Vegetated,

20=Herbaceous Tundra, 21=Wooded Tundra, 22=Mixed Tundra, 23=Bare Ground Tundra, 24=Snow or Ice
Attribute Definition Source: ARL
Attribute Domain Values:
Range Domain:
Range Domain Minimum: 1
Range Domain Maximum: 24
Attribute Units of Measure: Code
Attribute:
Attribute Label: AGRICULTURAL-METEOROLOGY greenness fraction
Attribute Definition: Percent of green plants at a grid point.
Attribute Definition Source: ARL
Attribute Domain Values:
Range Domain:
Range Domain Minimum: 0
Range Domain Maximum: 100
Attribute Units of Measure: Percent
Attribute:
Attribute Label: AGRICULTURAL-METEOROLOGY soil moisture liquid and frozen
Attribute Definition:
Twenty four hour average volumetric (liquid plus frozen) soil moisture (volume of water per volume of soil m3/m3) in a given layer. The four soil layers: 0-10, 10-40, 40-100 and 100-200 cm below ground
Attribute Definition Source: ARL
Attribute Domain Values:
Range Domain:
Range Domain Minimum: 0
Range Domain Maximum: 1
Attribute Units of Measure: m3/m3
Attribute:
Attribute Label: AGRICULTURAL-METEOROLOGY soil moisture liquid
Attribute Definition:
Twenty four hour average volumetric (liquid component only) soil moisture (volume of water per volume of soil m3/m3) in a given layer. The four soil layers: 0-10, 10-40, 40-100, and 100-200 cm below ground
Attribute Definition Source: ARL
Attribute Domain Values:
Range Domain:
Range Domain Minimum: 0
Range Domain Maximum: 1
Attribute Units of Measure: m3/m3
Attribute:
Attribute Label: AGRICULTURAL-METEOROLOGY canopy moisture
Attribute Definition: Depth of liquid water held by the leaves of the plant canopy.
Attribute Definition Source: ARL
Attribute Domain Values:

Range Domain:
Range Domain Minimum: 0
Range Domain Maximum: 1
Attribute Units of Measure: millimeter

Distribution Information:
Distributor:
Contact Information:
Contact Organization Primary:
Contact Organization: Army Research Laboratory
Contact Person: Manuel Bustillos
Contact Position: ARL MEL Administrator
Contact Address:
Address Type: mailing and physical address
Address: White Sands Missile Range
City: White Sands
State or Province: NM
Postal Code: 80002
Country: US
Contact Voice Telephone: (505) 678-2987
Contact Electronic Mail Address: `mbustill@arl.army.mil`
Hours of Service: 0800 - 1700 PST Monday - Friday
Resource Description: See Custom_Order_Process
Distribution Liability: None
Custom Order Process:
Technical Prerequisites:
MEL requires an HTML Browser, an Internet connection, email, and a use delivery site (email or anonymous ftp).

Metadata Reference Information:
Metadata Date: 20010829
Metadata Review Date: 19990218
Metadata Contact:
Contact Information:
Contact Organization Primary:
Contact Organization: Army Research Laboratory
Contact Position: Metadata Author
Contact Address:
Address Type: mailing and physical address
Address: White Sands Missile Range
City: White Sands
State or Province: New Mexico
Postal Code: 88002
Country: US
Contact Voice Telephone: (505) 678-3996
Contact Electronic Mail Address: `ljohnson@arl.army.mil`

Metadata Standard Name: FGDC - Content Standards for Digital Geospatial Metadata
Metadata Standard Version: FGDC-STD-001-1998
Metadata Time Convention: universal time

Acronyms

BFM	Battlescale Forecast Model
CKML	Conceptual Knowledge Markup Language
DAML	DARPA Agent Markup Language
DAML+OIL	DARPA Agent Markup Language + Ontology Inference Layer
DARPA	Defense Advanced Research Projects Agency
DCGS	Distributed Common Ground System
DIB	DCGS Integration Backbone
DoD	Department of Defense
DoDIIS	DoD Intelligence Information System
EO	electro-optical
GMDB	Gridded Meteorological Database
GFS	Global Forecast System
IMETS	Integrated Meteorological System
IT	information technology
IWEDA	Integrated Weather Effects Decision Aid
MM5	Fifth Generation Mesoscale Model
MSL	mean sea level
NCAR	National Center for Atmospheric Research
NCES	Net-Centric Enterprise Services
NDC	National Data Center
NGA	National Geospatial-Intelligence Agency
OIL	Ontology Inference Layer
OWL	Ontology Web Language
RDF	Resource Description Framework

RSOC	Regional Signals Intelligence Operations Center
URI	Uniform Resource Identifier
W3C	World Wide Web Consortium
XML	Extensible Markup Language

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